

Federal Family Summary on Delta smelt and Salmonids

September 13, 2011

I. Overview of the Entrainment Analysis for Delta Smelt-

Overall, the entrainment appendix shows an improvement from previous versions. Specifically, this document lays out a better understanding of the factors that contribute to entrainment and entrainment risk for delta smelt and other species. Concepts not previously mentioned are starting to develop in this draft version. However, there are parts of the appendix that are less developed than others. Since most of the impacts for delta smelt occur in the south Delta, more effort has been put into reporting those impacts. More thought will need to be put into characterizing the impacts of the north Delta intakes until the effectiveness of the diversion screens are fully evaluated; even if the most appropriate way to do this is qualitatively. It would be more helpful in future iterations for there to be an overall linking of all the pieces (life stages, species, covered activities, conservation measures) when reporting the results. Also, assumptions underlying each analytical method need to be fleshed out in the text before the reader can fully evaluate the appropriateness of the method (details provided below).

Suggestions for further necessary improvements:

- ❖ Do a better job describing the underlying assumptions of analytical methods that have not been peer-reviewed so the reader can fully evaluate the appropriateness of the method.
- ❖ Describe how the entrainment losses will be integrated together within any given year for various year types to get a better understanding of population impacts. Specifically, it would be helpful to identify years where cumulative losses are substantial and potentially problematic to species recovery and viability.
- ❖ For each entrainment method, describe how differences produced from each method may or may not lead to differences in the interpretation of the results to entrainment risk and population impacts
- ❖ The current Biological Opinions must be incorporated as currently written into assumptions, model inputs, and output analyses.

Comments on specific clarifications of the Entrainment Appendix are provided in the Federal Family Matrix. A more in-depth critique of the methods used in the Entrainment Appendix is provided for each life stage below. However, it should be clear that there was only limited time for our review of this document and that we assume it is not inclusive at this point in time, requiring our continued review and comment as additional appendices and modifications are provided.

The role of entrainment losses to the delta smelt population

The delta smelt population is currently at historic low levels and population losses generated from entrainment may have significant population effects depending on their magnitude and frequency (Kimmerer 2011). This Effects Analysis downplays the potential effects of entrainment to the population on page B11 (Section B.1.1.1), “[H]owever, analyses to date have not found correlation between entrainment and population level responses of delta smelt (e.g., Kimmerer 2008, Baxter et al. 2010).”

While it is true that regression analyses have failed to reveal an export affect to the delta smelt population, other methods have illuminated the role between SWP/CVP exports and population affects to delta smelt (Deriso and Maunder 2011; Kimmerer 2011). In fact, Kimmerer (2011) demonstrates that entrainment losses on the order reported in Kimmerer (2008) can be “...simultaneously nearly undetectable in regression analysis, and devastating to the population.”

The entrainment appendix acknowledges that the population effects of the water diversions will be handled in another chapter. However, I think the entrainment appendix needs to include a section on how estimated population losses from each life stage will be integrated together for inclusion in a life cycle model or some other framework for examining affects at an annual level. It should be noted once again, that delta smelt are an annual species that are at historic low population levels. In any given year, the proposed project may have detrimental and irreversible impacts to the population, especially if population distributes itself within the close proximity of the export facilities. The Effects Analysis needs to identify any problematic years where operations could compromise both adult and juvenile life stages given that evidence for density-dependence has been weak since 2002 (Kimmerer 2011). As best stated by Kimmerer (2011), “...losses at any life stage permanently and proportionally reduce the population from the trajectory it would have otherwise followed.”

South Delta Adult Entrainment Section

Kimmerer approach

The adult entrainment effects analysis uses three methods (Kimmerer approach, Manly-turbidity equation, salvage-density approach) that show relatively similar trends consistent with the premise that entrainment risk should increase as OMR flow becomes more negative (Kimmerer 2008; Grimaldo et al. 2009; Kimmerer 2011; Miller 2011). However, only the “Kimmerer approach” can reasonably be relied upon given that it has been vetted through the peer-review process. Adjusted entrainment estimates to Kimmerer’s estimates were also provided using methods described by Miller (2011). Miller’s estimates follow Kimmerer’s estimates but they are proportionally lower to account for periods when the population is distributed northward (i.e., Cache Slough Complex). Both methods are reasonable approaches to determine the effects of the proposed project given that future distributions cannot be reliably estimated in most water year types (excluding wet years and some critical years). However, it should be made clear that inferences about how entrainment affects the delta smelt population may differ from these two methods given they produce different total loss estimates in some year types. Additional review will be needed when the roll-up is provided to determine which method appropriately captures the effects of the proposed project in light of other conservation measures and stressors.

Manly-turbidity equation

Entrainment comparisons using the Manly-turbidity equation are a bit more difficult to interpret because it makes various statistical and biological assumptions that are not explicitly stated in the effects analysis. It would help if the unpublished manuscript cited in the effects analysis (Manly 2011) was made available for review. Not having reviewed the unpublished manuscript, it is impossible to

know if the assumptions underlying the Manly-turbidity equation are supported by the best available science. For example, the “Manly-turbidity approach” uses a normalizing technique for entrainment where both the previous FMWT index and an average FMWT index from 1996-2009 is included. It is not clear why this is done. I am guessing that he is attempting to normalize the effect of entrainment in any given year relative to the trend in the population. The primary problem with this approach is that it doesn’t recognize the step change that the delta smelt population experience during the POD years (Thompson et al. 2010; McNally et al. 2010; Kimmerer 2011). Another fundamental problem with the “Manly-turbidity approach” is that it uses hydrodynamic data from 1993-2009 years but salvage data from 1995-2009 (Section B.3.4.1, page B36). This mismatch between fish and hydrodynamic data does not make intuitive sense and one has to wonder if the equation would be less reliable if the data sets matched. Clearly, there is salvage data going back to 1993 and this data should be incorporated into the model. Another problem with the Manly-turbidity equation is that it only makes use of adult salvage data from December and January. By only using these two months, the equation fits a regression line that predicts entrainment quite reasonably ($r^2 = 0.86$). However, the short-coming of only using these two months is that it ignores, at times, high salvage events that might occur in February, March, and April (see Figure 3 in Kimmerer 2008). Adult delta smelt may migrate upstream anytime between December and April following the onset of first flush storms (see Figure 6 in Grimaldo et al. 2009).

The final problem with the Manly-turbidity equation approach is that it uses an assumption that future turbidity will be at levels consistent with 1990 or 2010. While it is true that water transparency is increasing in the south Delta, PTM modeling indicates that turbidity can be drawn across the Delta from the Sacramento River at OMR values less than -5000 cfs. Alternatively, wind re-suspension and local turbidity inputs from East Side rivers (i.e., Mokelumne, Consumnes) may create favorable rearing conditions for smelt in the south Delta which may expose them to entrainment risk at fairly modest OMR levels (i.e., -3000 to -1000 cfs).

Given all the limitations described above, the “Manly-turbidity approach” does not appear to be a useful tool for analyzing adult delta smelt entrainment at this moment without 1) explicit clarification of why the assumptions of the model itself are legitimate, 2) an expansion of the migration window (i.e., Dec-Mar/Apr) in the development of the model equation itself, 3) matching the fish and hydrodynamic data together from same years, and 4) a better description and/or documentation on the relationship between hydrodynamics and turbidity at local and regional scales as related to Sacramento River inputs, East Side River inputs, and wind driven re-suspension events.

Salvage-density method

One limitation of the salvage-density approach is that it assumes a linear relationship between salvage and exports. This limitation is clearly articulated in the effects analysis (Table B-6). However, another inherent problem with this method is that it relies only on salvage data and does not incorporate an estimation of total entrainment losses (i.e., unobserved salvaged due to poor screen efficiencies) which is important for interpreting population impacts (see Kimmerer 2008). Although this effects analysis states that the reviewers should focus on relative comparisons of salvage losses between the baseline condition and the proposed project, this method is inferior to the Kimmerer approach which estimates

population losses. Estimates of population losses are an improved method for looking at potential impacts of the proposed project given that the population of delta smelt is at extremely low levels (Kimmerer 2011). In short, this method could be removed from the effects analysis given that it does not provide useful metrics necessary for understanding population impacts of the proposed project to delta smelt.

South Delta larval and juvenile entrainment sections

Kimmerer approach

The Kimmerer approach is a reasonable tool for investigating the affects of the proposed project on larval and juvenile entrainment losses. However, the analysis employed in the effects analysis only examined the months of May and June. Kimmerer (2008) clearly shows that larval losses are often highest during April (see Figure 14) when water temperatures reach peak hatching levels (~15° C; Bennett 2005). In short, the method needs to include April. March may need to be included if climate change scenarios predict warmer water temperatures (i.e., consistently reaches 15°C) in the month of March. Although the effects analysis states that PTM and the Kimmerer approach are not all that reliable for juvenile fish that are capable of swimming, Kimmerer (2008; see Figure 16) demonstrates that juvenile salvage data follow PTM estimates of entrainment loss quite well.

The assumptions underlying the Miller approach on the larval/juvenile smelt section needs to be fleshed out in more detail given that the results contrast starkly to results produced using the Kimmerer approach. It appears that Miller applied multiplication factor that is not properly documented in the Miller (2011) manuscript. Until the more information is provided on the method, this approach cannot be fully evaluated at this time.

PTM estimates of larval/juvenile smelt losses with and without uniform distributions

The effects analysis uses PTM analysis to determine larval and juvenile entrainment losses between baseline and proposed project conditions using various assumptions of where larvae are hatched. The uniform distribution assumption provides the most unbiased approach given that future hatching distributions cannot be reasonably inferred for most water year types under current conditions. The “starting distribution approach” was applied to make inferences of entrainment risk of larvae and juveniles under various water year types. In this approach, the locations of ripe females from the SKT data from the most recent surveys (2002-2009) were summarized for the available water types as prediction points as to where these fish may spawn in these water year types in the future. Among the problems with this approach, the biggest is that the starting distribution of larval smelt inferred by location of ripe females in the SKT does not match where larval smelt actually hatch. The 20 mm survey predicts, at times, a drastically different starting distribution for larvae from the SKT trawl data (<http://www.dfg.ca.gov/delta/projects.asp?ProjectID=20mm>). In short, this method produces results with very low interpretive value for most water year types given that the underlying assumptions of starting distribution are unreliable. Further, the results from this method do not corroborate the results of Kimmerer (2008) which shows quite different larval and juvenile entrainment for years 2002, 2003, and 2005. To date, the OMR-X2 equation in the 2008 FWS BiOp provides the highest statistical

explanatory value to predict larval and juvenile entrainment losses. This method should be incorporated in the effects analysis and the starting distribution approach should be removed given its limitations described above.

Salvage-density approach

As stated for adults, the salvage-density provides little interpretative value beyond a comparative tool for examining the direction and relative magnitude of salvage if exports under the proposed project increase or decrease relative to the baseline. The Kimmerer approach is much more informative given that it generates population loss estimates for the larval and juvenile life stages.

North Delta Entrainment sections

Modeling Assumptions

At times not all key modeling assumptions were provided to the reader, making it difficult to determine if the modeling was performed properly. This comment applies to almost all of the models used to estimate entrainment.

Assess Species Exposure to North Delta Intakes

Delta Smelt Eggs/Embryos

Impacts to delta smelt eggs/embryos were concluded to not occur or would minimally occur through subject of entrainment, as stated in Table B-2 & B-4. However, no rationale is provided within the text of the analysis to expand upon the justification for this statement in the table provided early-on in the document. Recommend providing a justification (with appropriate references) within the appropriate section of the document. This comment applies to other species, such as longfin smelt.

Screening Effectiveness Analysis

Screen Efficiency vs. Entrainment Efficiency vs. Survival Efficiency

Within the Fish Facilities Technical Team (FFTT), the five agencies defined screen efficiency as the physical adjustment of screen size to account for the structural portions of the screen to pass flow. Likewise, survival efficiency was defined as the fish moving past the screen from one end of the screen to the other, and entrainment efficiency as fish going through the screen based on the size distribution of fish and the slot size opening. Sometimes, uses of these concepts were unclear or they were used interchangeably throughout the text. We suggest adding these terms to the glossary as we continue reviewing subsequent appendices to provide more clarity to the meanings of the various parts of the analyses.

Delta Smelt Larva, Juvenile, & Adult

The screening effectiveness analysis methods for loss of fish through entrainment provide very little description for the 'qualitative evaluation of entrainment and impingement risk' [Page B-69 & 70] that would occur under the construction and operation of the new north Delta diversions. When looking to the results for that qualitative evaluation [for delta smelt and other species], there is a light reference to a review of literature and abundance and distribution data, but no thorough evaluation. There is a statement on Page B-305 that cites no data exists within the vicinity of the diversions; however, there is data available from the USFWS beach seines, DFG [Delta Smelt/]Striped Bass Egg and Larval Surveys, and North Bay Aqueduct (NBA) Larval Fish Surveys, and possibly more. Not much is reported as to what the review of the literature results concluded. Recommend providing a more robust 'qualitative' analysis than what is provided, utilizing all available scientific literature and data. This comment extends beyond the delta smelt results and applies to all the covered species results.

Methods - Impingement Loss

The water diversions proposed under the BDCP have the potential to cause entrainment and *impingement* of the proposed covered species at their various life stages. It would be more appropriate to title the Appendix, Entrainment and Impingement. Entrainment and impingement are different modes for causes of injury, harm, and mortality to aquatic organisms that should be discussed within the Chapter 5, Effects Analysis.

Page B-69 lines 24-28 of the Screening Effectiveness Analysis (ND Intakes) methods states that there would be an assessment for both entrainment and impingement on the north Delta screens. This discussion on impingement was absent within the document. There has been recent research efforts conducted [by Swanson, Young, White, and Cech at UC Davis] specifically to inform the BDCP that should be reviewed and acknowledged in the effects analysis to discuss the likelihood of a delta smelt coming in contact with a screen. If no quantitative analysis can be performed regarding the impingement of species with the screen, it is recommended that there at least be a qualitative analysis describing the potential impacts to covered species from impingement and screen contact. The results of those studies concluded that there are impingement risks and some level of mortality associated with the operation of diversions such as these. After prolonged screen contact, mortality increases. The effects were most pronounced and aggravated under dark conditions. The analysis should not be limited to downstream movement of delta smelt and salmonids, but should also consider upstream movement as part of the analysis when determining impacts to delta smelt.

Particle-Tracking Modeling [DSM2]

Current sweeping velocity assumptions assume an average flow for the channel as being the same as the velocity directly in-front of the screen for determining if criteria are being met. More accurate assumptions could be developed to better characterize the sweeping velocity in-front of the screens. More accurate assumptions will lead to a more likely estimate of water being diverted from the north Delta facilities.

Additional Impingement References for Delta Smelt

[Note: These references are starting points to further developing the literature review for delta smelt impingement. More literature is available as well for the other covered species in the Plan.]

Young, Paciencia S., Swanson, Christina and Cech Jr., Joseph J. (2010) 'Close Encounters with a Fish Screen III: Behavior, Performance, Physiological Stress Responses, and Recovery of Adult Delta Smelt Exposed to Two-Vector Flows near a Fish Screen', Transactions of the American Fisheries Society, 139: 3, 713-726, First published on: 09 January 2011 (iFirst)

White, David K., Swanson, Christina, Young, Paciencia, S., Cech, Jr. Joseph J., Chen Zhi Qiang and Kavvas, M. Levent (2007) 'Close Encounters with a Fish Screen II: Delta Smelt Behavior Before and During Screen Contact', Transactions of the American Fisheries Society, 136:2, 528-538, First published on: 09 January (iFirst)

Swanson, Christina, Young, Paciencia. S. and Cech Jr, Joseph J. (2005) ' Close Encounters with a Fish Screen: Integrating Physiological and Behavioral results to Protect Endangered Species in Exploited Ecosystems', Transactions of the American Fisheries Society, 134: 5, 1111-1123, First published on: 09 January 2011 (iFirst)

II. Overview of the Entrainment Analysis for Salmonids

The goal of the document is to characterize the risk of entrainment for the BDCP covered species under the six modeled water operations scenarios. There are several improvements in this document to the organization and to the analytical approaches used to assess entrainment. In particular, the inclusion of exports by water year type and the monthly schedule of diversions from the north and south Delta provided a useful context to better understand results related to entrainment among the scenarios. In addition, several alternative methods were provided and results were shown as building blocks for individual analyses (for example normalized vs. non-normalized salvage for Chinook).

This builds confidence in the objectivity of the technical approaches and allows for transparency in testing particular assumptions. Evaluation of multiple approaches provides data on the variance around estimates and builds a “weight of evidence” foundation that has been lacking in previous versions and will be useful in the final roll-up. We also appreciate the improved acknowledgement of uncertainty in the various methods compared to the last analysis of entrainment, and feel that the table detailing the benefits and limitations of each method is a nice summary.

The effects of the PP water operations are particularly pronounced in the south Delta in April and May (the two critical months for steelhead and fall-run Chinook salmon emigration; Fig B-5). Given the increase in entrainment of salmonids in drier years it is difficult to envision how the PP will achieve the goal of improved south Delta conditions in these years (i.e., CM 1 dual conveyance). A challenge for all EA appendices will be to link the enhancer/stressor to a meaningful population-level metric (abundance, viability, diversity). The entrainment analyses for steelhead and Chinook salmon currently fall short of achieving this. Both the salvage-density and DPM analyses could be improved to better relate entrainment to population indices.

The methodology for normalization to population size needs to be clarified and further discussed, as there is a fair amount of confusion over exactly how the results were normalized. It appears that the average adult escapement for the same year as salvage was used, and this is probably not the best method. Please see our detailed comments for suggestions.

We understand that the Delta Passage Model is undergoing revision as a result of significant technical input at a June 2011 workshop. It is unclear whether the revisions to date have been incorporated into the presented results. Likewise, we expect results to be corrected once the final model revisions are complete. Additionally, while the DPM is a useful tool for this analysis, we still question the applicability of the model to spring-run and winter-run Chinook, and to salmon fry; the uncertainty of results for these runs should be explicitly stated. We also have some suggestions for improved ways of presenting the output to better present them in a population context.

There are many potential indirect effects of the Preliminary Project that were not evaluated in this appendix, which was focused on direct mortality caused by a strict definition of entrainment. We would like to see the following items evaluated at some point in the Effects Analysis:

1. How the proposed water operations might exacerbate predation beyond background levels, including the impact of the hydraulic zone of influence (HZI) on fish behavior.
2. Better information on the mortality rates of salmonids after they are released back into the Delta".
3. An analysis of how the proposed North Delta diversions might increase entrainment via increasing the proportion of fish routed into the Central Delta if reverse flows increase at the Georgiana Slough/Sacramento River junction.

Some of these analyses might be more appropriate for the technical appendix on flows, but we are uncertain if they will be included in that appendix.

Questions for further discussion with ICF and DWR:

1. Are there any plans to analyze project effects on individual fish populations, such as the Calaveras River steelhead population or Mokelumne River fall run Chinook? Currently, the species are categorized only as Sacramento or San Joaquin River fish.
2. We are wondering exactly how much of the analysis presented in the Effects Analysis technical appendices will be conducted for each of the EIR/EIS project alternatives.

Major technical comments:

The summary table B-2 is a welcome addition to providing a tabular summary of the entrainment results. For example, it was illuminating to see that spring-run entrainment may increase >75% due to the PP in drier years. However, interpreting what the symbols actually referenced was challenging. Did the several symbols bracketed within a // refer to monthly averages? What analytical methods did each

bracketed section refer to? It would be helpful to try and develop a key that would be more informative to help guide the reader to the section that these results were summarizing. For example, for spring-run juveniles in below normal year, the summary table shows (+++/++++). Is this the salvage-density results/DPM? How were the results rolled up to 50-75%/75% increase in entrainment?

B.3.4 Salvage-density method

B.3.4.1 Preprocessing of input data

One of the major limitations of this method for salmonids is the inability to accurately differentiate runs of salmon based on size criteria. This is appropriately caveated. However, there is better science now available to reconstruct salvage rates for different runs from 1996-2009 using SAMGEN (DWR's genetic database; Brett Harvey). The data that went into the salvage-density analysis span the same years where genetic run ID is now available. Recommend using this database to accurately determine spring-run vs. fall-run fish in the salvage to estimate run-specific densities and re-run analysis.

B.3.4.2 Normalization to population size

Salvage is thought to be a function of several biological and hydrological factors. One of the primary drivers of high salvage is thought to be large population size for Chinook salmon. This is an important variable to factor out or "normalize" to place the salvage numbers into the proper demographic context and determine the role of water operations vs. large population size on salvage. It is unclear based on the description provided what calculations were actually conducted. The text implies that the monthly salvage was normalized to a measure of average population size in that year. This seems like a reasonable approach (albeit a measure of juveniles exiting Chipps Island would be a better index to develop- see details below). If adult escapement is being used, then **Annual** adult escapement from the brood year corresponding to salvage should be used (not an averaged population size over several years) and a table from Grand tab needs to be provided. The equation used to normalize monthly salvage should be provided. When looking at the normalized vs. non-normalized salvage results, it was not possible to reconstruct the different numbers in the table.

An alternative to the adult method of normalization is to use the Kimmerer 2008 approach and attempt to use a juvenile production estimate to relate to salvage. Kimmerer (2008) used cwt fish collected at salvage and related that to fish that exited the delta at Chipps Island. This concept should be replicated and a similar Chipps island "flux" index developed for each of the salvage years for this analysis (see Kimmerer 2008 for how to develop this or discuss with Pat Brandes). The real metric we want is the number of fish salvaged relative to the number of fish that exit the delta (e.g., at Chipps). This would help in normalizing the data for useful comparisons among water year types. For example, in wetter water years, more fish may be salvaged but more may also be exiting at Chipps Island too. What we really care about is whether different water operation scenarios create a significant deviation from the proportion salvaged vs. exit in different water years. It is expected that fewer fish are salvaged in drier years than wetter years, yet those fish salvaged in drier years may be more valuable demographically to the population than those salvaged in wetter years (due to higher in-river mortality). There needs to be

a way of evaluating the effect of water year in normalization or in relating back to the % juvenile abundance.

B.3.4.3/4 Entrainment index calculation and proportional entrainment

Kimmerer (2008) demonstrates a non-linear salvage-export relationship. If a linear one is being assumed in the density calculation, it would be useful to discuss in the broader context of where export values for the PP occur on Kimmerer's Fig. 10. It would be informative to acknowledge the deviation or conformity to linearity for the given export flows- this would provide the context for whether fish salvaged is proportional to number of fish exiting Chipps or higher due to export flows (this is the premise of the equation developed by Kimmerer (2008) in comparing the greater proportion of cwt fish that end up at the facilities relative to captured at Chipps Island as a function of higher exports).

The expression of the loss data to the total "juvenile abundance index" needs to be significantly modified or removed from the analysis as currently formulated (Table B-8). It would be more informative to incorporate the juvenile production variation in emigration that occurs based on adult abundance and hydrology (see recommendation in 'normalization') for ideas on how to better refine this.

Results tables need better self-supporting descriptions and labeling. For example, Table B-59 and all other tables with this format are unintelligible. Is the number in the cell the difference (subtraction) of the loss (EBC-PP)? Therefore a (-) value is an increase in loss? I suspect that the - number is a decrease in loss, so the title of these tables and or a footnote is necessary. The same is true for the %. Describe what that actually is. This is particularly important since values range from -66% to + 94(!).

Delta Passage Model

The entrainment estimate is a smaller component of the overall DPM model output. A significant amount of technical input has been provided on improvements to the model. Given the complexities and inter-relatedness of parameters of the model, an explicit update on how the recommendations from the DPM workshop relating to entrainment were incorporated would be useful (e.g., recommendations from Newman on different values for theta). Given that one of the outputs from the DPM is % of fish that exited at Chipps, I recommend reporting the number salvaged to the number that successfully outmigrated as a valuable population metric that places the entrainment as a function of water operations results into a more meaningful context.

Results tables need to be consistent with the salvage-density format (order between PP vs. EBC or EBC vs. PP). In fact, are they the opposite from each other? Is the number in the cell the difference (subtraction) of the loss (EBC-PP)? Therefore a (-) value is an increase in loss? Crosswalk with salvage-density for ease in interpretation.

